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STATEMENT FOR THE RECORD

BY

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PRESENTED TO THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ON

"RESEARCH INSTRUMENTATION NEEDS OF UNIVERSITIES"

Mr. Chairman and Members of the Subcommittee:

This statement describes the status of our work on the research instrumentation needs of U.S. universities. We are conducting this work in response to a letter from Chairman Schmitt (dated July 29, 1981) in which he requested GAO to do a study that:

--analyzes studies and other relevant data to determine the causes and factors which influence the need for research equipment by universities; and

--identifies and evaluates options available for equipping university laboratories, including Federal programs, alternative financing plans, and depreciation schedules and tax incentives.

In this statement we will discuss our work to date on the first half of this request.

BACKGROUND: UNIVERSITIES AND INSTRUMENTATION

Under the present organization of the U.S. research and development effort, universities conduct the major share of basic research.

In 1981, the universities and their associated research centers spent about $5.2 billion on basic research, which was about 59 percent of the Nation's total basic research expenditure.

For about 20 years, U.S. scientists have claimed, in studies and congressional testimony, that instrumentation available to academic researchers was inadequate, due primarily to insufficient funding. In recent testimony, various leaders of the scientific community have estimated the cost of updating university research equipment to lie between $1 billion and $4 billion. A more precise total does not exist. The variation reflects the lack of consensus on what a well-equipped scientist ought to have and on the number of scientists that should be well equipped.

SCOPE AND METHODOLOGY OF THE GAO STUDY

Our ongoing work does not attempt to determine how many university scientists lack adequate equipment. Nor do we attempt to determine how many scientists should be equipped or how sophisticated that equipment ought to be. Finally, we are not analyzing the impact of equipment shortages on research output.

Our objective is to analyze why this perceived shortage of research equipment exists. We draw on three sources of information:

1. Expenditure data drawn primarily from various publications of the National Science Foundation (NSF).
2. Major existing studies of the need for university research equipment. With few exceptions, these studies are concerned with demonstrating that an accumulated research equipment need exists, rather than assessing the causes of this perceived shortage. An annotated list of the major studies is attached to this statement.

3. The result of interviews with over 200 researchers and administrators during site visits to 8 universities, 4 private research or business organizations, and 4 Federal agencies. The universities were selected on the basis of a combination of characteristics: research eminence, amount of research expenditures, geographic location, and the level of financial support from non-Federal sources.

For the analysis that follows, we define research equipment as instrumentation used in scientific experiments which can be installed in a given laboratory without large physical plant modifications or new construction. While this definition is a useful start, data problems remain. No trend data exist on nationwide research equipment expenditures by universities. (NSF is studying how such data could be collected.) Similarly there do not exist comprehensive indexes which would measure changes in the price of equipment or the costs to maintain it. We rely on our interviews and a few small studies for this information.

INFLUENCES ON UNIVERSITIES AFFECTING EQUIPMENT ACQUISITION

Existing studies of research equipment needs identify the following principal causes for the perceived shortage:

--constant funding for basic research,

--increased acquisition and maintenance costs for instrumentation, and

--inflexibility in the granting process.

Based on our own analysis and interviews, we add to this list:

--financial disincentives contained in Office of Management and Budget (OMB) Circular A-21, and

--the apparently common practice of funding research staff in lieu of replacing aging research equipment.

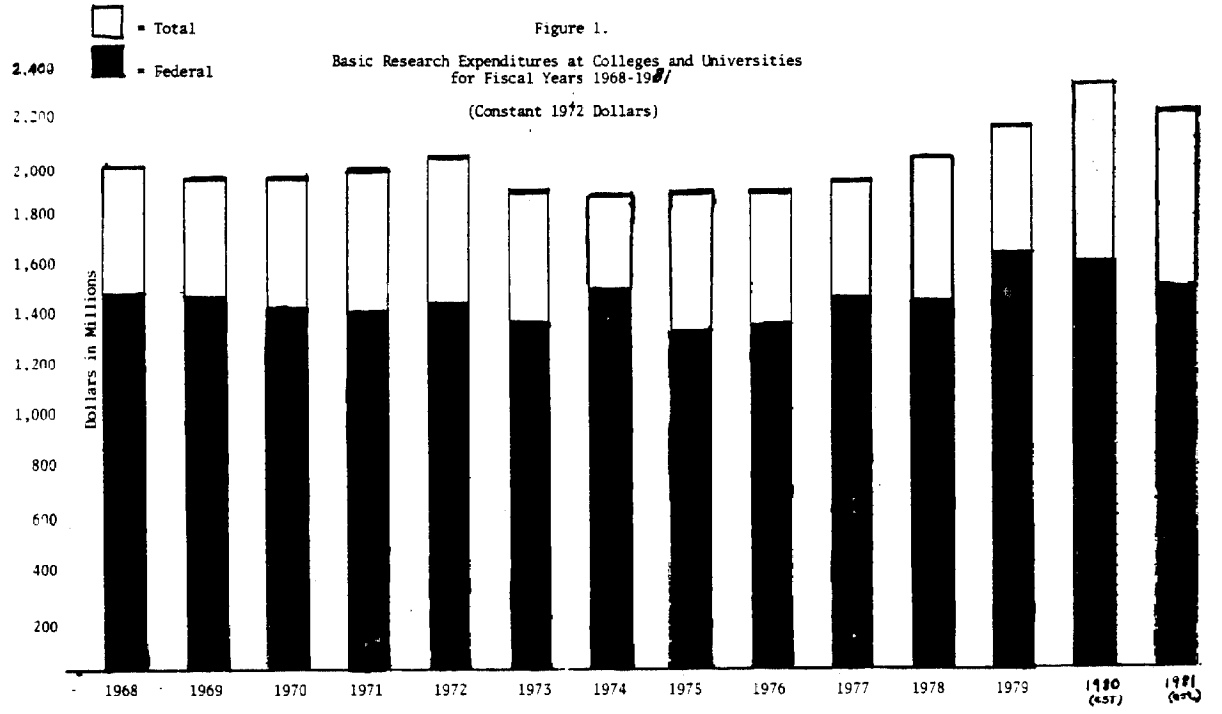
Funding for Instrumentation

Except for some yearly fluctuation, between 1968 and 1977, constant dollar (1972) expenditures for basic research at colleges and universities were essentially constant. 1/ An upswing began in 1977 but expenditures declined from 1980 to 1981. Overall expenditures increased 10 percent in constant dollars from 1968 to 1981, with the major increase occurring since 1976. Figure 1 shows this overall trend, as well as the share of expenditures by the Federal Government.

Figure 1.

Basic Research Expenditures at Colleges and Universities for Fiscal Years 1968-1981/

(Constant 1972 Dollars)



Increasing Cost of Instrumentation

In light of essentially constant funding, as indicated above, major price increases have had a large effect on researchers' acquisition and maintenance of research equipment.

1/All data in this section come from various NSF publications.

All available data, although limited in amount, support the contention that the price of advanced research equipment has increased faster than the general inflation rate. Most of these calculations are on the basis of increasing costs to do a particular kind of research, rather than on the increasing cost of a particular piece of equipment. However, in a study of the IBM Research Division, it was calculated that a "market basket" of about 126 items of research equipment increased in cost at a 16.4 percent annual rate between 1975 and 1981. 1/ A 1980 Association of American Universities (AAU) study 2/ cites figures of over 20 percent for annual cost increases from several data sources for research equipment used in chemistry.

Maintenance costs also have been cited as increasing rapidly. The 1980 AAU report presents a staggering example of costs which doubled for a particular facility over a 4-year period. A 1971 National Academy of Sciences (NAS) study 3/ estimated average maintenance costs at 10 percent of the original cost of an instrument per year. Science magazine noted that equipment maintenance service charges have reached $100 per hour in some instances, which includes travel time for the technician. Our interviewees generally confirmed the occurrence of maintenance cost increases. However,

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1/Draft Report of the Ad Hoc Working Group on Scientific Instrumentation, National Research Council, 2 April 1982, p. 35.

2/The Scientific Instrumentation Needs of Research Universities, 1980.

3/An Assessment of the Needs for Equipment, Instrumentation, and Facilities for University Research in Science and Engineering, 1971.

we have been unable to locate any aggregate data on maintenance need and costs.

Inflexibility in the Granting Process

The present research grant funding process makes it very difficult for several researchers to jointly purchase expensive instrumentation to be shared during their research projects. This is especially true when the grants come from more than one agency. This point was made by many researchers with whom we spoke. NSF is conducting a promising experiment in its research grant administration which, among other characteristics, would facilitate multiproject purchases of research equipment. Early indications are that researchers are making some use of this new concept to more easily purchase expensive equipment. However, this experiment is just a beginning. It does not address the difficulty associated with groups of researchers attempting to acquire instrumentation from several agencies during the proposal stage of the research funding process.

OMB Circular A-21

Under the formula in Circular A-21 for calculating rates for cost recovery for federally funded research, there are two provisions which may be causing problems for universities. First, the portion of a university's equipment purchased with non-Federal funds is considered to be used at a rate of 6-2/3 percent per year which is equivalent to a useful life of 15 years. This provision ostensibly exists to enable the university to recoup funds for the renewal of equipment as it wears out. However, the 15-year recoupment may not be consonant with scientific advancement and its

requirement for new equipment design. The NAS 1971 report estimated that the useful life of laboratory equipment may be closer to 5 years, while researchers we have interviewed claim that for some quickly advancing fields it is sometimes less than that. Second, Circular A-21 does not allow a university to be reimbursed for interest expenses. We were told that this adds to a university's difficulty in raising funds to acquire equipment which is not purchased with Federal funds. If recent OMB-proposed changes in Circular A-21 are adopted, interest charges for equipment costing over $25 thousand will be allowed.

Trading Equipment for Research Staff Salaries

Principal investigators have been forced to make choices to keep research proposal costs within overall budget constraints. We were told repeatedly by senior researchers and university administrators that when times are tight, the first proposed expenditure to be cut is for new equipment. The investigators appear to do their best in keeping money to pay their research team--the associated faculty, post doctoral researchers, and graduate students. It may take many years to develop a strong team of researchers to do a particular kind of research. When the choice is between letting go a research associate and buying equipment, it appears that a research team can always "make do" with a particular piece of aging equipment for another year.

Unfortunately, there is no documented evidence of the magnitude of these trade offs of equipment purchase for people support. This appears, however, to be a common occurrence in every university laboratory we visited.

Perhaps researchers make these trade offs in the belief that they have no alternative. Perhaps the practice is increased due to the difficulty in determining with any precision when a particular piece of equipment is obsolete and needs to be replaced.

We can distinguish between two kinds of obsolescence--physical and scientific. Physical obsolescence refers to an item that breaks down and is no longer seen worthy of repair. This does not occur at any precise time--it seems that equipment can frequently be repaired. Determining whether to repair a piece of equipment may depend on many factors such as the time and ease of repair, cost of repair, availability of parts, and cost of replacing a piece of equipment. An appropriate analogy may be with an automobile owner with an aging car. At what point will it no longer be worthwhile to repair a car and, instead, purchase a replacement?

Scientific obsolescence is even more difficult to define. It can occur long before breakdown (physical obsolescence) or even before the instrument is no longer capable of generating data that contributes to published results. The ambitious researcher wishes to advance his/her research at a rapid pace. If a piece of equipment does not enhance that research effort by providing appropriate technological assistance, it is seen as scientifically obsolete. However, that same instrument may have years of useful life remaining for research performed by other scientists with different research objectives.

We found no methods that can determine absolutely when scientific obsolescence has occurred. We were told repeatedly by researchers that, if they couldn't purchase or get access to a

particular piece of equipment, they would attempt to alter their research objectives to compensate. However, such flexibility for individual researchers, combined with continued deferred investment, may not translate into the best use of our scientific capabilities.

Existing studies attempt to determine obsolescence of laboratory facilities by comparing the "best" university laboratories with similar laboratories in other nations and with facilities in industrial laboratories. The 1980 AAU report noted, and our interviews corroborated, that many scientists in the best university laboratories have seen research laboratories overseas that have far more modern research equipment for similar research. However, there are no studies that systematically document this by comparing the state of equipment available to basic researchers in various countries.

The 1980 AAU report on university research instrumentation needs presents limited data comparing the best university and industrial laboratories. AAU concluded from its small sample that the median age of equipment in industrial facilities was almost half that of the best university laboratories. Thus, they concluded that on the whole, the industrial facilities were far more advanced.

CONCLUSION

In this statement we have described several causes for the perceived need for research equipment. In every case, there is a tremendous lack of information. We believe more information is needed to assist policymakers in assessing whether the need is diminishing or growing; and developing standards on what constitutes a "normal level" of research equipment need.

ANNOTATED BIBLIOGRAPHY OF MAJOR STUDIES

The following 13 studies are particularly descriptive of the state of university instrumentation. They are listed alphabetically by title.

An Assessment of the Needs for Equipment, Instrumentation, and Facilities for University Research in Science and Engineering. National Academy of Sciences, September 1971.

This study evaluates the equipment needs of research universities as indicated by a sample of 8 science and engineering departments in each of 10 major disciplines. This was the first study to document the deteriorating research equipment situation across the major fields of science in the "post-Sputnik" era. It called for an ongoing effort to monitor and assess instrumentation needs in all major science and engineering disciplines.

Chemistry: Opportunity and Needs. National Academy of Sciences, National Research Council, Washington, D. C., 1965.

This study is one of several discipline-oriented studies sponsored by the National Academy of Sciences in the mid-1960s through the early 1970s. Instrumentation is one of many issues studied that are related to chemistry. The study looks at the history and uses of instrumentation for basic research, and examines the cost and financing of instruments. It provides documentation of a national deficiency in instruments in university chemistry departments.

Equipment Needs and Utilization. Final Report to the National Science Foundation Advisory Council, 1978.

This study was done by Task Group #5 of the National Science Foundation Advisory Council. The objective (task) of the group was "to discuss and document research equipment needs within the university environment, and the role of Federal funding in alleviating these needs. Included would be the replacement of obsolete equipment and acquisition of additional equipment and related facilities." This study contains a comprehensive set of findings and recommendations.

Expenditures for Scientific Research Equipment at Ph.D. Granting Institutions, FY 1978. Irene L. Gomberg and Frank J. Atelsek. Higher Education Panel Report, Number 47, American Council on Education, March 1980.

The American Council on Education, through its Higher Education Panel, studied the university equipment situation for the National Science Foundation. The study collected information for the 1978 fiscal year on the level of institutional expenditures for research equipment, the Federal contribution to those expenditures, and the share of the funds spent on high-cost items. This

is the only study that attempted to collect data on expenditure for equipment by all disciplines.

Extramural Instrumentation Funding by the National Institutes of Health. Prepared by Dr. Kirt J. Veneer, April 1981.

The purpose of this report was "to retrospectively view and comment upon the fact of equipment requests made as part of regular research grants as they moved through the review process prior to funding." Three types of data were reviewed: evidence put forward to substantiate obsolescence claims; the funding of equipment by all Bureaus, Institutes, and Divisions in the National Institutes of Health (NIH); and the pattern of funding for two NIH institutes. This study provides a unique description of the extent to which a single Federal agency contributes to the funding of research instrumentation as a part of project-oriented research programs.

The Life Sciences. Committee on Research in the Life Sciences and Public Policy, National Academy of Sciences, Washington, D. C., 1970.

Like the previously mentioned study on chemistry, this was also one of several discipline-oriented studies sponsored by the National Academy of Sciences. Instrumentation is one of several dimensions of life sciences that are examined. Instrumentation is examined as a tool of biological research and as a requirement "for the future of the academic endeavor in the life sciences." Separate questionnaires were used to collect data from individual academic scientists and from department chairmen.

The Nation's Deteriorating University Research Facilities. A Survey of Recent Expenditures and Projected Needs in Fifteen Universities. Prepared for the Committee on Science and Research of the Association of American Universities, Washington, D. C., 1981.

This study is a companion to the 1980 AAU report on instrumentation needs (listed below). It was a preliminary investigation into some of the unanswered questions raised by earlier studies concerning facilities. Expenditures for the last three years and anticipated spending for four years were collected from 15 universities for new construction, facility modernization, major repair and renovation, and special research equipment. The sources of funds were not identified in the data.

Research Equipment Assistance Program: A National Science Foundation Research Management Improvement Project Research Report. Volume I - Basic Report; Volume II - REAP Office Procedure Guide; Volume III - Computer Support User Manual; Volume IV - Implementing an Equipment Assistance Program. Iowa State University, October 1976.

The objective of the study was "to describe a cost effective, rapid response system for assisting faculty researchers and teachers

with scientific equipment and equipment-related needs through sharing, loans, and transfers. Faculty cooperation in sharing was achieved through a voluntary system independent of property accounting." This program forms a model for other universities to copy in their effort to meet Federal requirements for equipment sharing.

The Scientific Instrumentation Needs of Research Universities. A Report to the National Science Foundation by the Association of American Universities, June 1980.

The principal objectives of this study were "to assess the current status of scientific instrumentation in the major research universities and to identify factors which either facilitate or impede its development, acquisition, use and maintenance." Estimates were made "of the future consequences of current instrumentation funding policies on the capacity of the research universities to conduct productive research."

Shared Use of Scientific Equipment at Colleges and Universities, Fall 1978. Frank J. Atelsek and Irene L. Gomberg. Higher Education Panel Report, Number 44, American Council on Education, November 1979.

This survey "gathered information about the kinds of formal and informal procedures colleges and universities follow to facilitate sharing of scientific equipment . . . . The methods of sharing range from small-scale cooperative arrangements between departments to sophisticated institution-wide computer maintained systems." This is the only study to systematically collect data on the shared use of scientific equipment at colleges and universities.

The Snowbird Report - A Discipline in Crisis. Computer Science Board (1980 Biennial Meeting). Communications of Associations for Computing Machinery, Volume 24, Number 6, 1981.

This report was developed during the 1980 biennial meeting of Computer Science Department Chairmen. It is the result of intensive discussions about the crisis in computer science. Brief mention is made of the need for "computing facilities capable of sustaining experimental research." An appendix to this report shows the levels of capital investment per researcher required for different standards of research facilities.

The State of Academic Science: The Universities in the Nation's Research Effort. Bruce L. R. Smith and Joseph J. Karlesky. New York, Change Magazine Press, 1977.

This study examined the universities' role in the Nation's R&D effort. It discusses instrumentation needs as one of several emerging issues in academic research. It identified "the deterioration of instrumentation and other supporting resources for

academic research" as one of four factors that was causing "uncertainty and anxiety" about the continued strength and vigor of the academic science enterprise in the United States.

A Study to Improve the Management of Costly Instrument Centers. A Report to the National Science Foundation by the Department of Chemistry, University of Utah, 1975.

In this study, the authors "examined the distribution of major instruments and the various forms of management practices involved in instrumental support of chemical research which have evolved in the U.S. and selected foreign countries." The authors also attempted "to assess operating costs of instrumental services under varying circumstances." Information on both the instrumentation situation in Europe and on the operations and needs of chemical instrumentation centers are unique contributions to the understanding of the situation.